AUGUST 2019

WIM #42
US 61,
MP 119.6
COTTAGE GROVE,
MINNESOTA

MONTHLY REPORT

Your Destination...Our Priority

WIM Site Location

WIM #42 is located on US 61 near Cottage Grove in Washington county.

System Operation

WIM #42 was operational for the entire month of August 2019. Volume was computed using all monthly data.

System Calibration

WIM #42 was most recently calibrated on 2019-05-13. Table 1 summarizes the front axle weights of class 9s by lane [1]. Figure 1 shows the distribution of gross vehicle weights (GVW) in Class 9 vehicles at this site for the last 12 months of operation [2]. Figure 2 depicts the average front axle weight as a percent difference from the first full month following calibration.

Summary of Volume Statistics

Total Monthly Volume: 1121913 | Passenger Vehicles: 1064211 | Heavy Commercial Vehicles: 57702

Monthly Average Daily Traffic (MADT): 36075 | Monthly Heavy Commercial Average Daily Traffic (MHCADT): 1861

See Table 2 for vehicle class breakdown

Passenger Vehicles (PVs) and Heavy Commercial Vehicles (HCVs)

Volume trends. NB vehicles typically reached highest volume levels on Fridays, with lowest volumes reported on Mondays. SB vehicles typically reached highest volume levels on Fridays, with lowest volumes reported on Sundays (see Figure 3 and 4).

Passenger Vehicles (PVs)

Volume trends. On an average 24-hour day (see Figure 5), NB PVs generally reached peak volume levels between 03 PM and 05 PM. Similarly, SB PVs peaked in volume between 03 PM and 05 PM

Heavy Commercial Vehicles (HCVs)

Volume trends. On an average 24-hour day, HCVs traveling NB typically reached peak volume levels between 03 PM and 05 PM, while volume going SB peaked between 03 PM and 05 PM. See Figure 6. Out of all HCVs, the two highest traffic volumes were generated by Class 9's and Class 5's.

Overweight HCVs

Volume trends. Of a total of 57702 HCVs, 9127 of them were overweight [3]. These overweight HCVs contributed to 0.8% of total monthly volume, and 16.2% of total monthly

HCV volume. NB overweight vehicles typically reached highest numbers on Thursdays, with lowest volumes reported on Sundays. SB overweight vehicles tended to reach highest volumes on Mondays, with lowest volumes reported on Saturdays. See Figure 3 .
The top two overweight violators by class were the class 9 and class 10 vehicles . Overall, overweight vehicles tended to reach peak volume concentrations during typical business hours, with 52.2% of all overweight vehicles traveling SB this month (see Figure 7 & 8).
Figure 9 shows the number of vehicles exceeding 88,000 pounds that crossed the WIM over the last 12 months. The highest number of 88,000+ vehicles within the last 12 months occurred in June.
WIMs are currently used as a screening tool for weight enforcement, and it is estimated that the WIM scales can measure gross vehicle weights (GVW) within 90-95% of static weight scale measurements. Due to the possibility of measurement error, vehicles exceeding 10% of their legal weight limits (or 1.1 times their legal weight limits) are considered overweight in this report [4].
Using normal load limits ,180 NB vehicles exceeded 88,000 pounds (111 vehicles were Class 9's; 41 vehicles were Class 13's). Of vehicles traveling SB,

1056 NB vehicles exceeded 88,000 pounds (850 vehicles were Class 9's; 105 vehicles were Class 10's). Refer to Table 3 for the Top 10 highest recorded GVWs from Classes 9 and 10 from August 2019.

Loaded vs. Unloaded HCVs. Figure 10 shows the GVW distributions of Class 9s and 10s in August 2019. Data suggests that there were greater numbers of fully_loaded Class 9's than empty Class 9's traveling NB, while there were more empty Class 9's than fully_loaded traveling SB. Data also suggests that there were more fully_loaded Class 10's than empty traveling in the NB direction. In the SB direction, there were more empty class 10 vehicles.

Freight Totals. A total of 447055 tons of freight was recorded to have crossed the WIM. More freight was shipped NB (53.3%) than SB (46.7%). See Table 4 and Figure 11 for more freight information.

####**Infrastructure Considerations Bridge.** Bridge No. 5895 (Hastings Bridge) is approximately 1.9 miles south of WIM #42, and Bridge No. 82J16 is 1.0 miles north of WIM #42. WIM #42 recorded a total of 1121913 vehicles with a combined GVW of 7030299 kips (1 kip = 1,000 pounds = 0.5 tons) in August 2019. See Table 5 and Figures 12-13 for GVW information by vehicle class and lane.

Pavement Design. A total of 43893 equivalent single axle loads (ESALs) passed over the pavement at this site. Approximately 51.2% of all ESALs were recorded SB while 48.8% was observed NB. In particular, 63% of all ESALs were generated by the Class 9's (Class 9's were also responsible for generating 18% of total GVW observed this month). See Table 6 and Figures 14-15 for more information on ESALs (Table 6 also provides flexible ESAL factors for each vehicle class using a terminal serviceability of 2.5 and a structural number of 5).

#####WIM monthly reports can be found at:
http://www.dot.state.mn.us/traffic/data/reports-monthly-wim.html MnDOT's vehicle

classification scheme and vehicle class groupings for traffic forecasting can be found at: http://www.dot.state.mn.us/traffic/data/data-products.html#weight

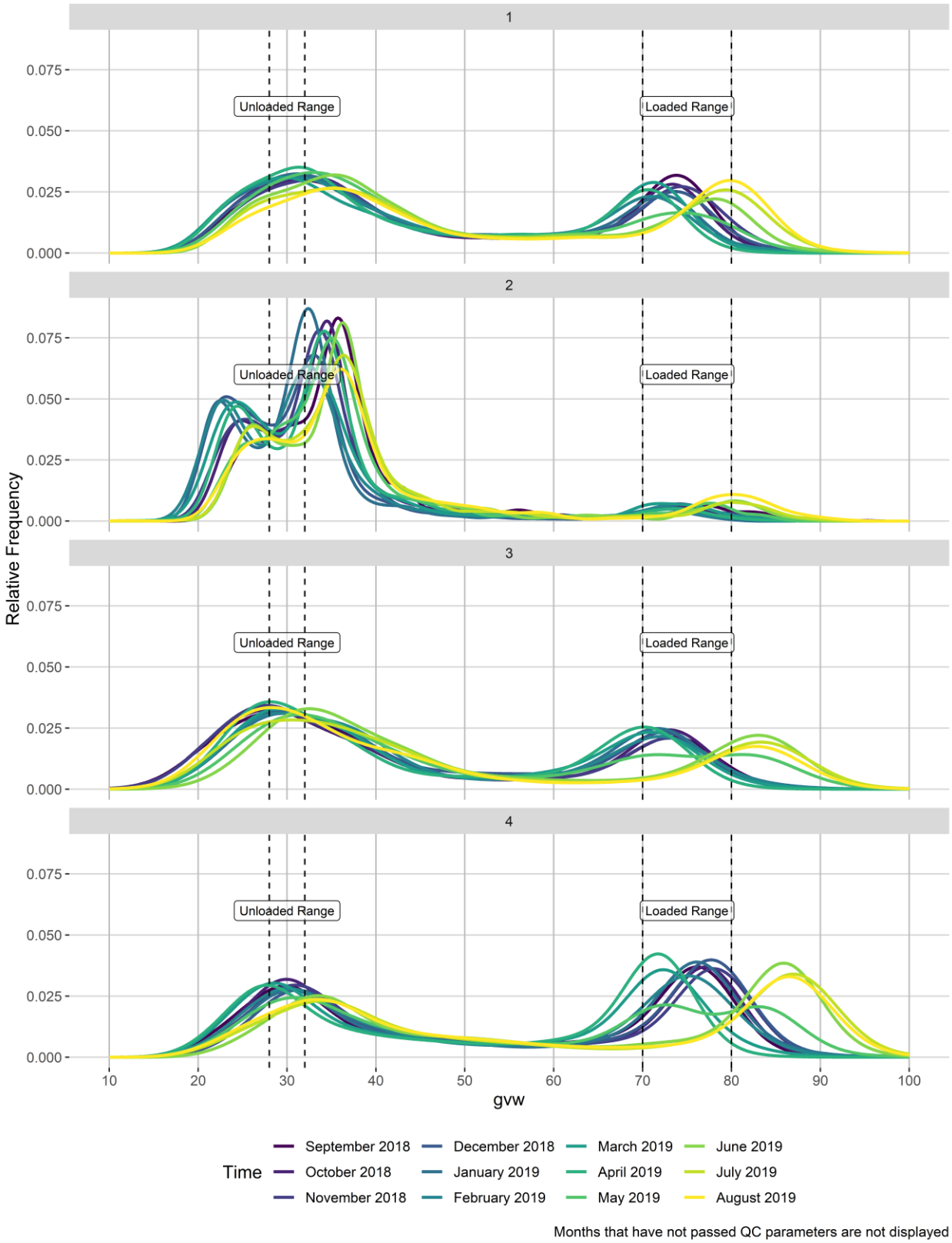
- [1] Front axle weights of Class 9s are monitored on a monthly basis to assure performance between calibrations. The current goal of the WIM scale calibration is to have each individual axle weight stay within a range of ?9% of baseline calibration values

- [2] Previous WIM research indicates that unloaded Class 9s typically weigh 28-32 kips, while loaded Class 9s generally fall in the 70-80 kip range. More recent data from several WIM sites suggests that the unloaded Class 9 range may have moved a little higher over time (due to increased presence of sleeper cabs, etc.), although these ranges are also thought to be site-specific.

- [3] An HCV is considered overweight during normal load limits in this report if they satisfy any of the following 1) exceed a gross vehicle weight (GVW) of 80,000 pounds, 2) exceed any of the legal weight maximums on any axle configurations (legal maximums are: single axle = 20,000 pounds; tandem axles spaced 8' or less = 34,000 pounds; tridem axles spaced 9' or less = 43,000 pounds; quad axles spaced 13' or less = 51,000 pounds). Monthly reports use this standard regardless of the time of year however, the Winter Load Increase (WLI) allows a 10% across the board increase in axle and gross vehicle weights without a permit on US, state routes, and county roads. An HCV is considered overweight during Winter Load Increase(WLI) if they satisfy any of the following 1) exceed a gross vehicle weight (GVW) of 88,000 pounds, 2) exceed any of the legal weight maximums on any axle configurations (legal maximums are: single axle = 22,000 pounds; tandem axles spaced 8' or less = 37,400 pounds; tridem axles spaced 9' or less = 47,300 pounds; quad axles spaced 13' or less = 56,100 pounds). An overweight HCV is only included once in the overweight volume calculations regardless of how many of the aforementioned conditions are violated. For information on MN weight limit dates and statutes: http://www.mrr.dot.state.mn.us/research/seasonal_load_limits/sllindex.asp

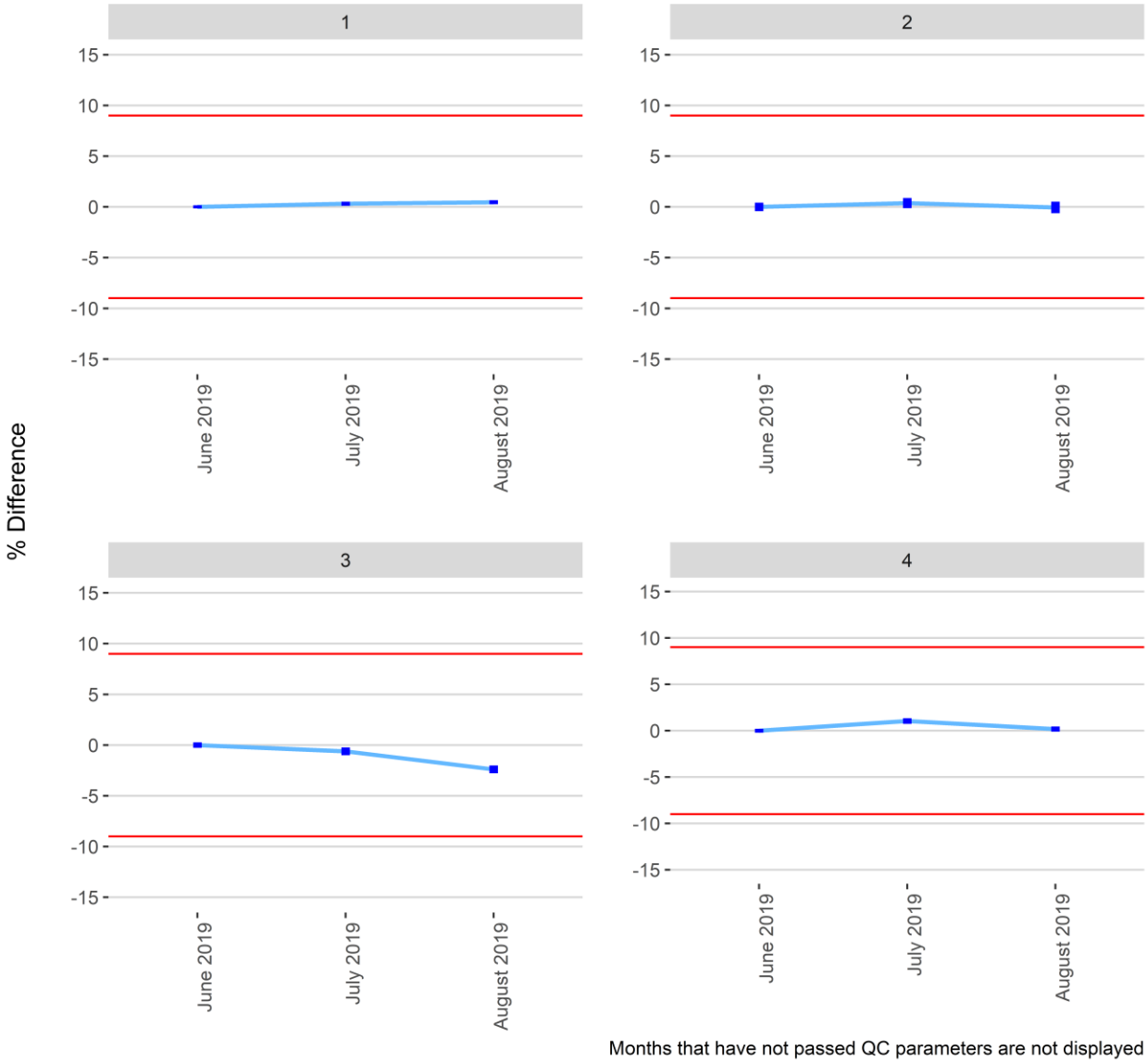
- [4] For example, Class 9s and 10s can legally have gross vehicle weights up to 80,000 lbs (with the exception of permitted loads) during normal load limits. To account for measurement error on the WIM scales, those exceeding 10% of the legal GVW maximum (or 1.1 times the legal GVW) should be screened (e.g., 80,000 lbs + 8,000 lbs = 88,000 lbs). Similarly during WLI vehicles weighing 96,800 lbs should be screened.

Figure 1 - Monthly Class 9 GVW Histogram



Months that have not passed QC parameters are not displayed

Figure 2 - Percent Difference of Front Axle Weight from Last Calibration (+/- 95% CI)



Months that have not passed QC parameters are not displayed

Figure 2 - Average Vehicle Volume
vs. Day of the Week

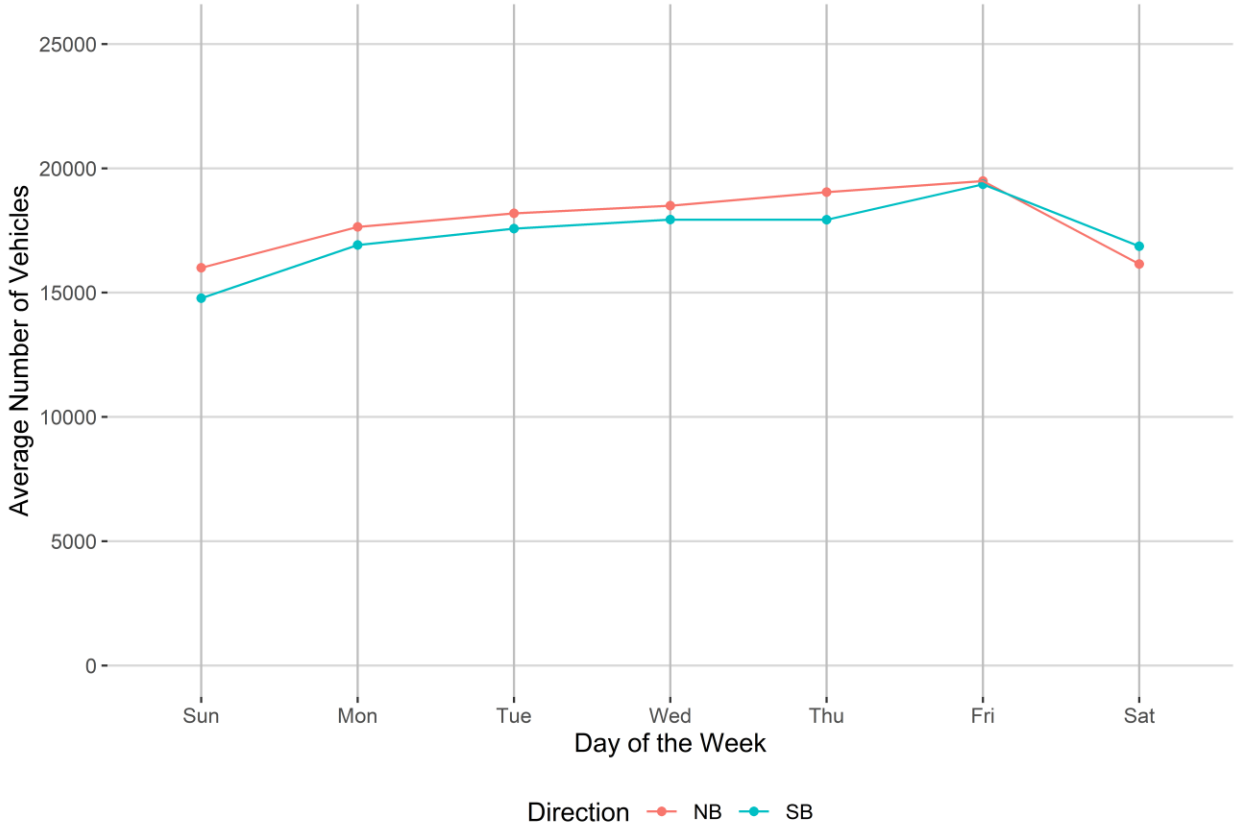


Figure 3 - Average Overweight Vehicle Volume
vs. Day of the Week

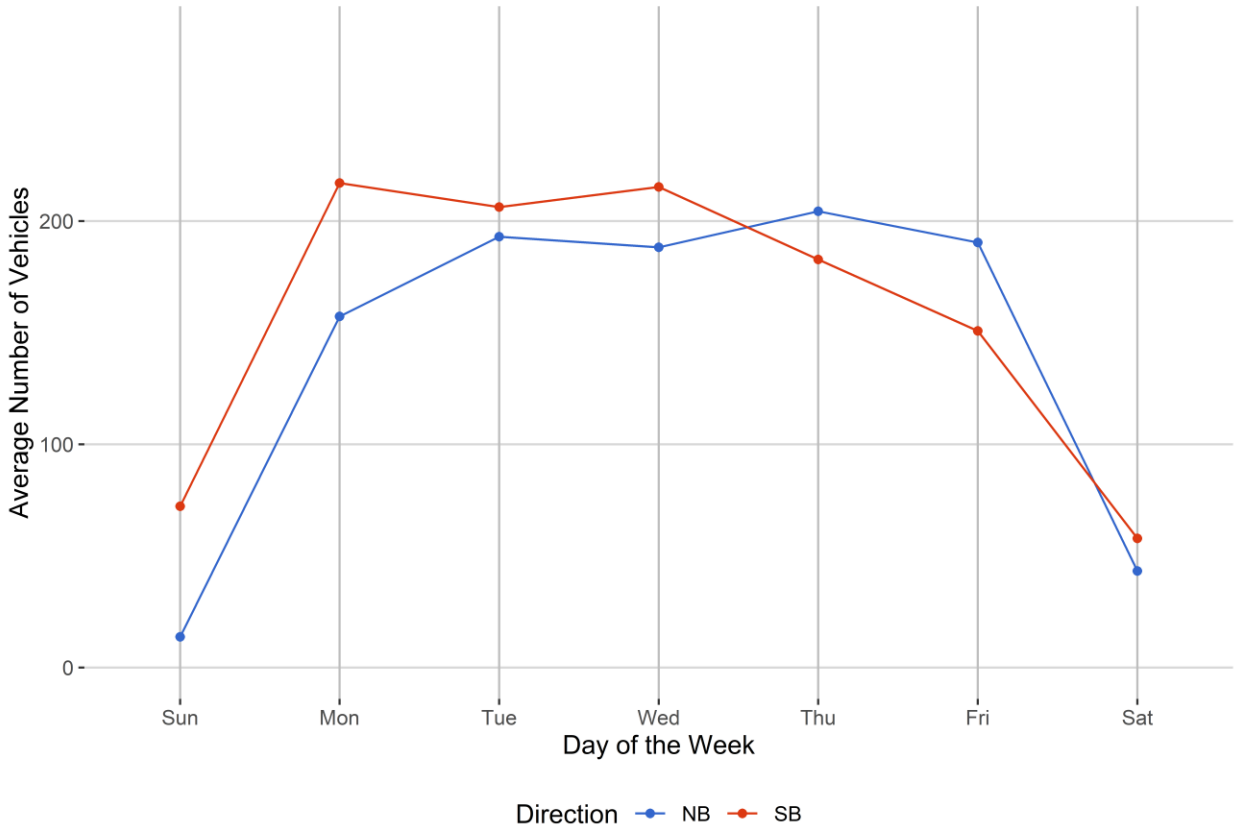


Figure 4 - Passenger Vehicles vs. Hour of the Day

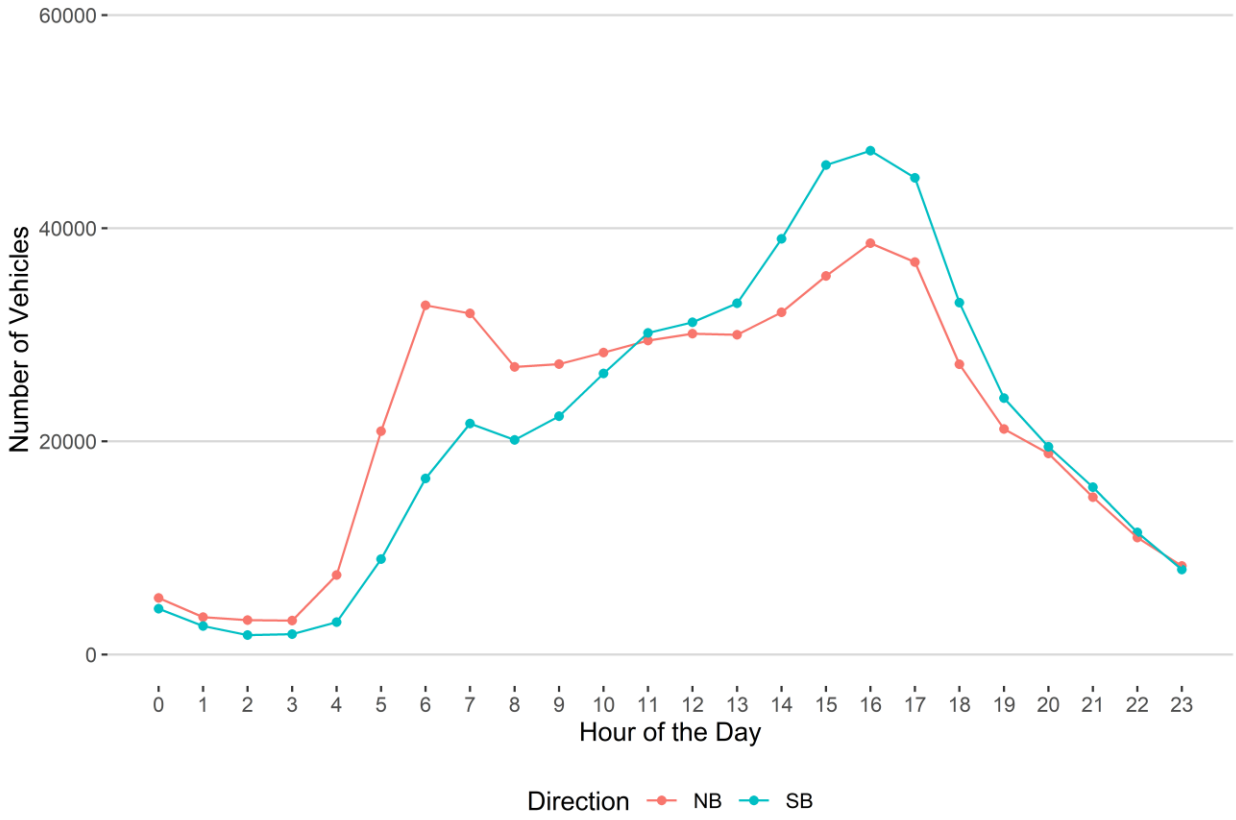


Figure 5 - Heavy Commercial Vehicles vs. Hour of the Day

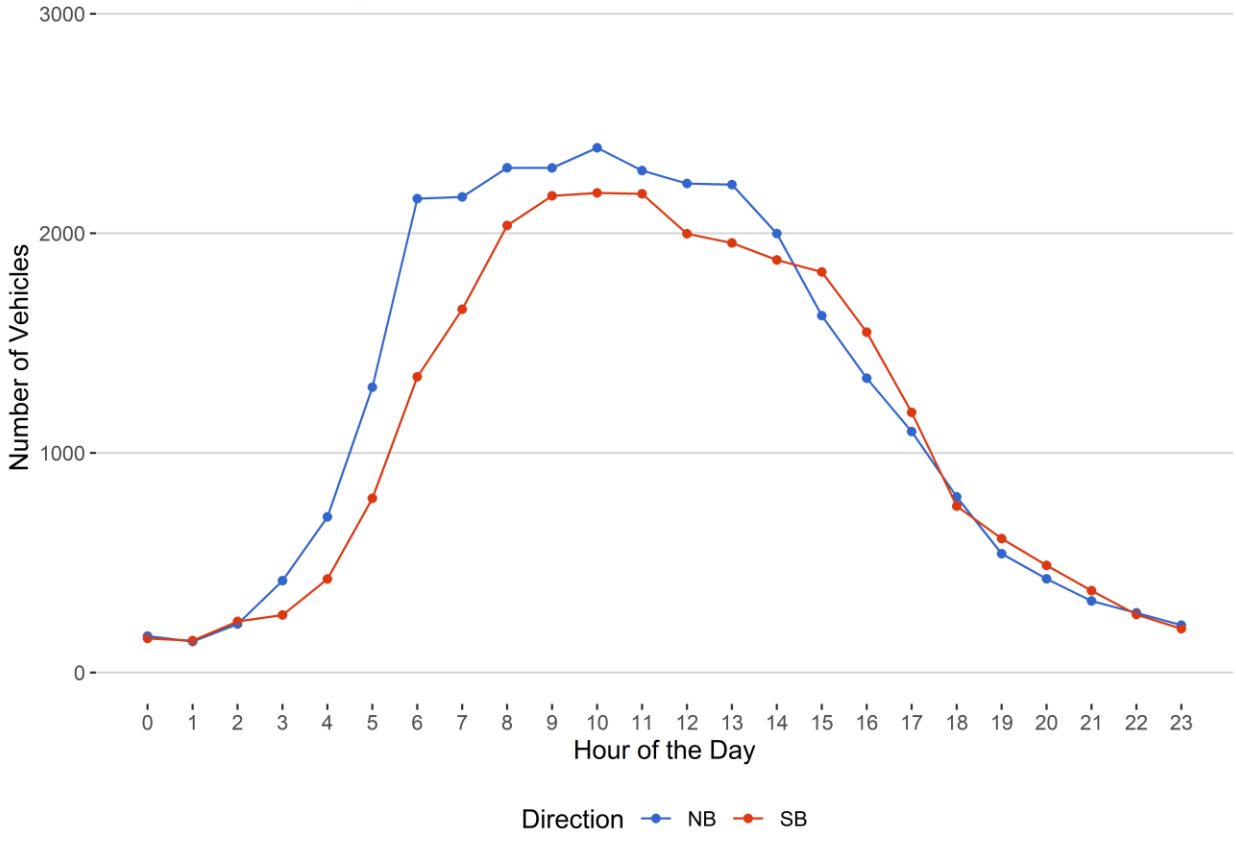


Figure 6 - Overweight Vehicles by Class vs. Hour of the Day

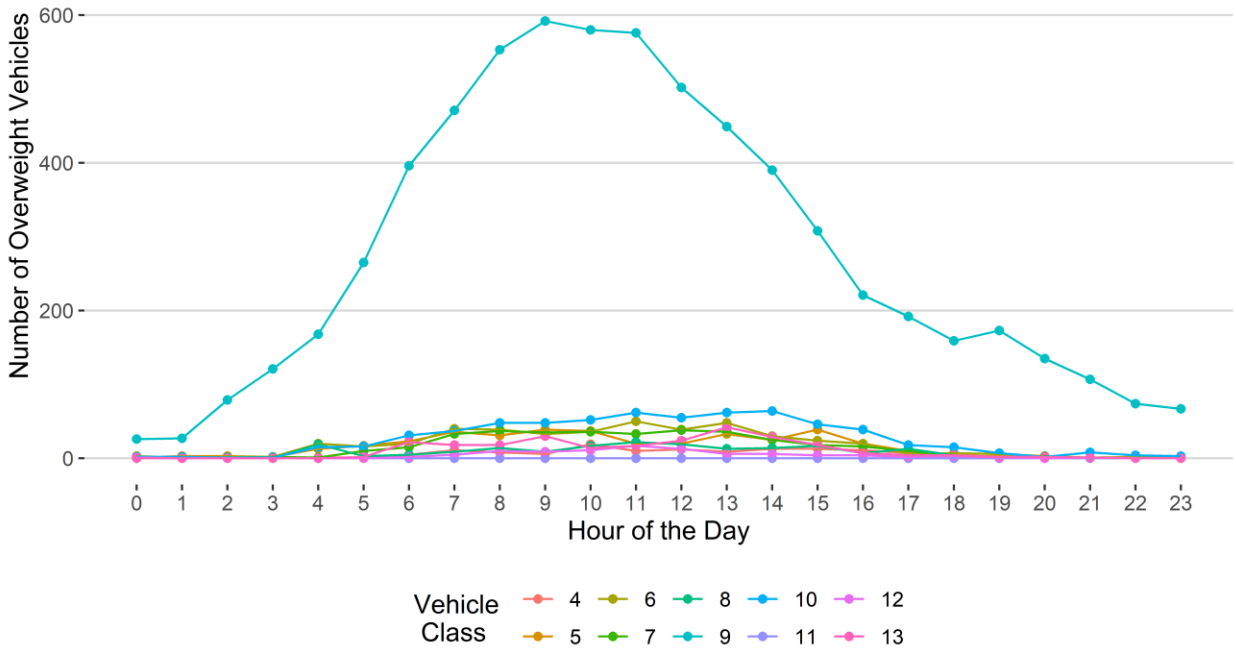


Figure 7 - Overweight Vehicles by Direction
Hour of the Day

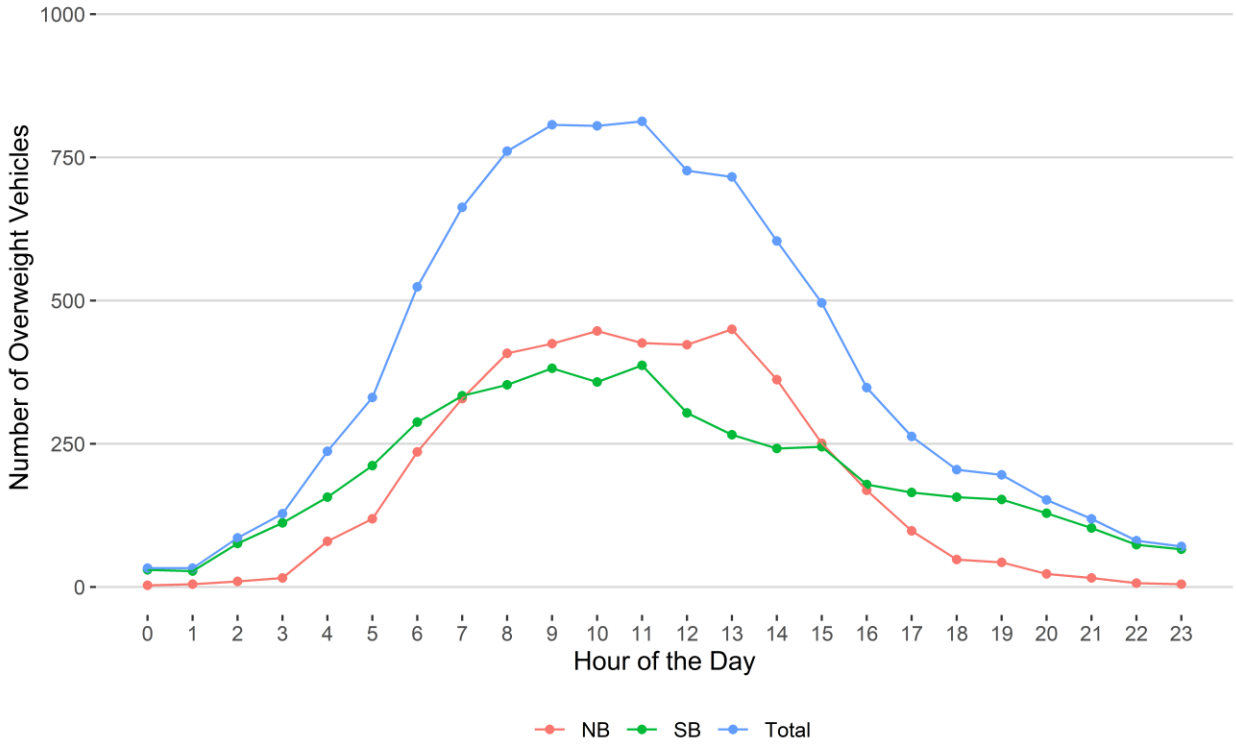
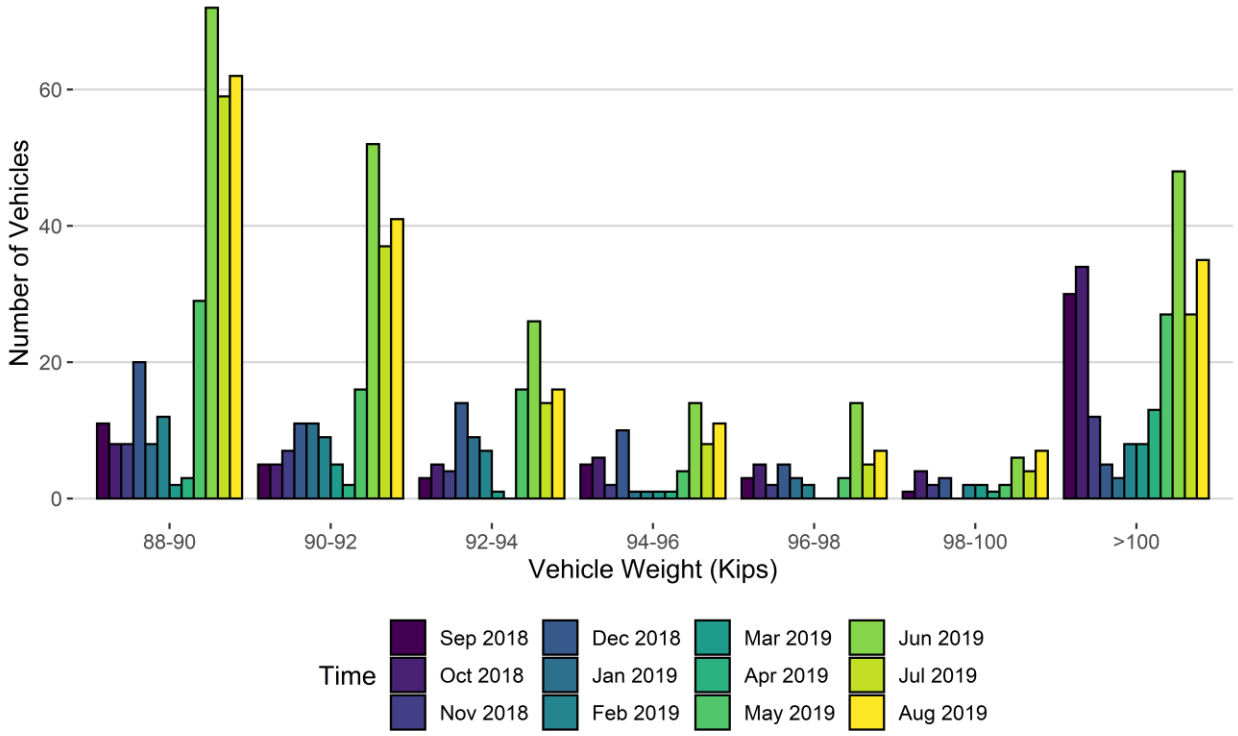
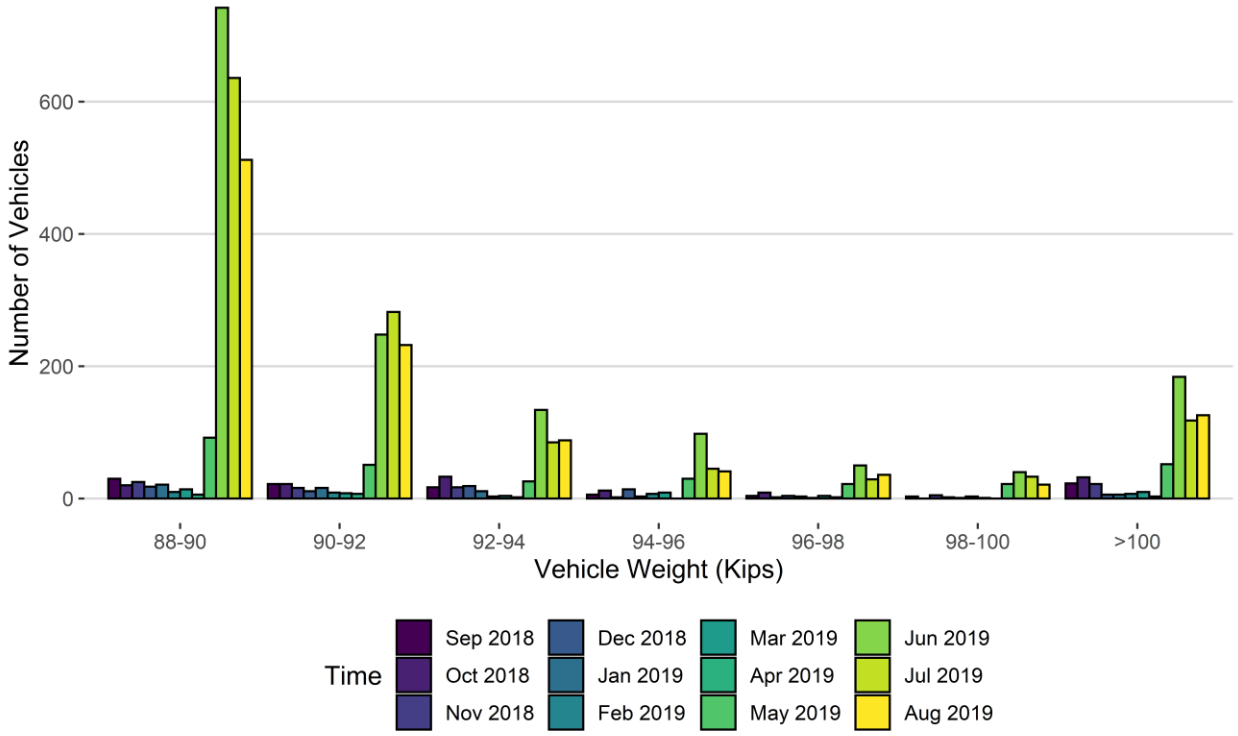


Figure 8 - Histogram of NB Vehicles Over 88,000 Pounds for Current Month



Vehicle Weights (Kips)	*Sep 2018*	*Oct 2018*	*Nov 2018*	*Dec 2018*	*Jan 2019*	*Feb 2019*	*Mar 2019*	*Apr 2019*	*May 2019*	*Jun 2019*	*Jul 2019*	*Aug 2019*
88-90	11	8	8	20	8	12	2	3	29	72	59	62
90-92	5	5	7	11	11	9	5	2	16	52	37	41
92-94	3	5	4	14	9	7	1	0	16	26	14	16
94-96	5	6	2	10	1	1	1	1	4	14	8	11
96-98	3	5	2	5	3	2	0	0	3	14	5	7
98-100	1	4	2	3	0	2	2	1	2	6	4	7
>100	30	34	12	5	3	8	8	13	27	48	27	35
Total	58	67	37	68	35	41	19	20	97	232	154	179

Figure 8 - Histogram of SB Vehicles Over 88,000 Pounds for Current Month



Vehicle Weights (Kips)	*Sep 2018*	*Oct 2018*	*Nov 2018*	*Dec 2018*	*Jan 2019*	*Feb 2019*	*Mar 2019*	*Apr 2019*	*May 2019*	*Jun 2019*	*Jul 2019*	*Aug 2019*
88-90	30	20	25	18	21	10	14	6	92	742	636	512
90-92	22	22	16	11	16	9	8	7	51	248	282	232
92-94	17	33	17	19	11	3	4	2	26	134	85	88
94-96	6	12	2	14	3	7	9	0	30	98	45	41
96-98	4	9	2	4	3	1	4	2	22	50	29	36
98-100	3	0	5	2	1	3	1	0	22	40	33	21
>100	23	32	22	6	6	7	10	3	52	184	118	126
Total	105	128	89	74	61	40	50	20	295	1496	1228	1056

Figure 8 - Class 9's and 10's by Direction vs Gross Vehicle Weight

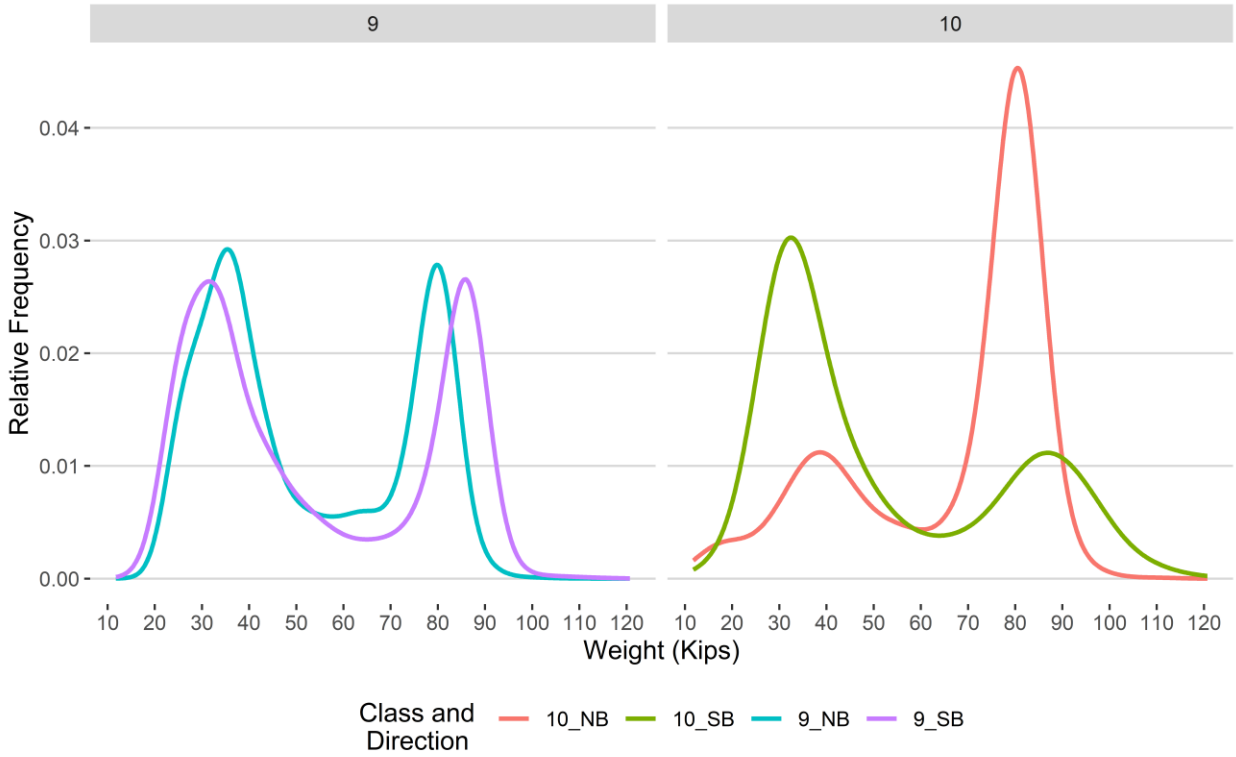


Figure 9 - Freight Percentage by Direction and Class

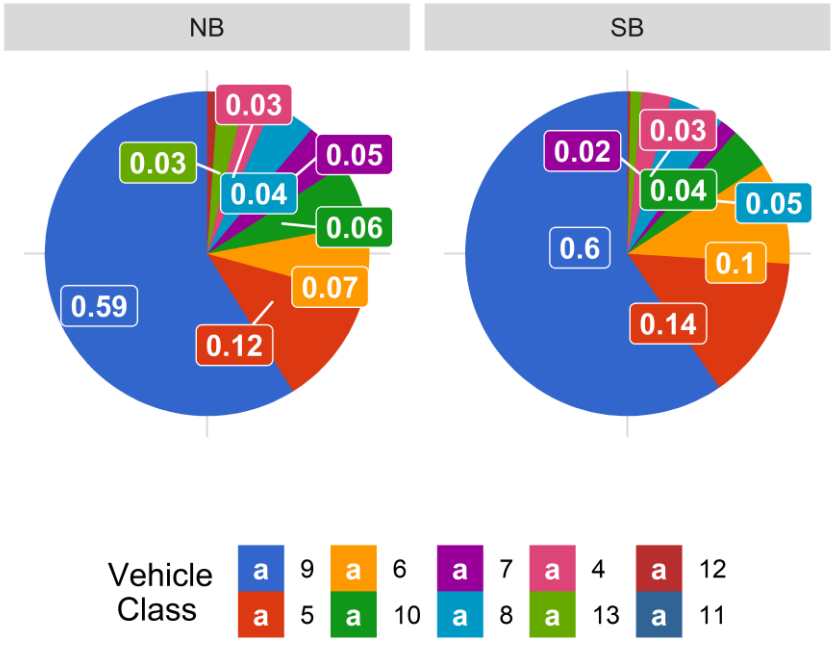


Figure 10 - Total Gross Vehicle Weight Percentage by Class and Lane

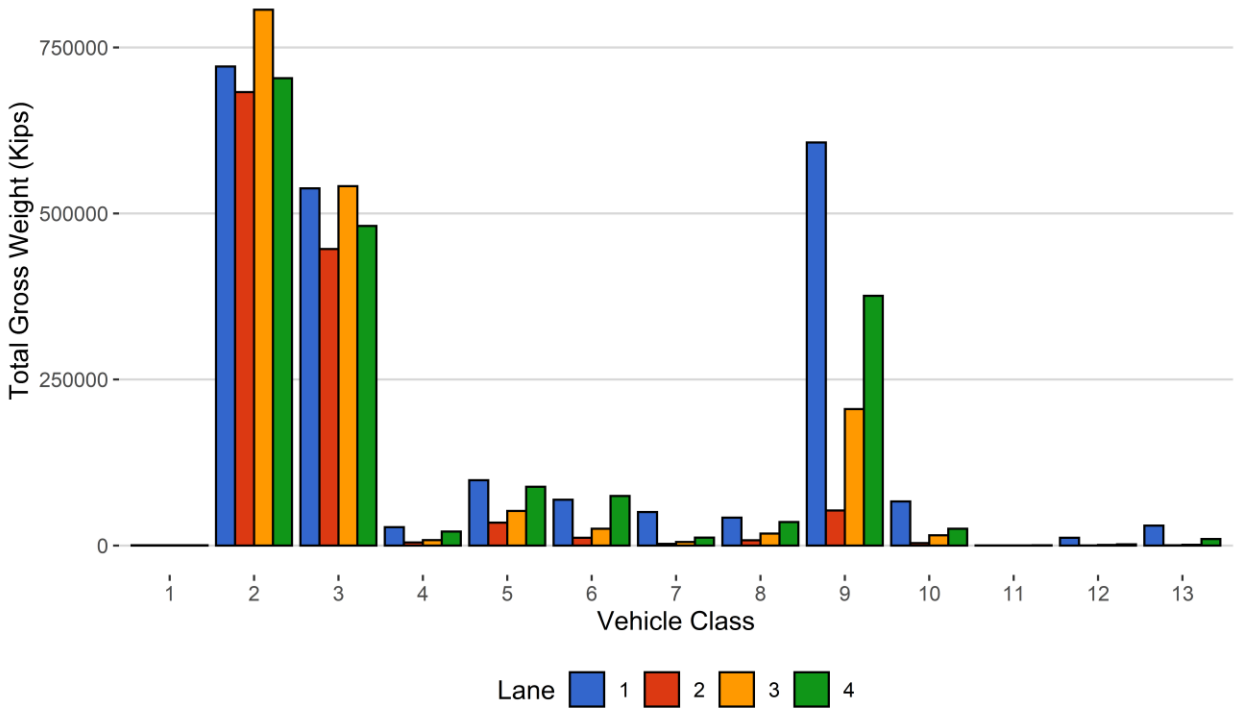


Figure 11 - Total Gross Vehicle Weight

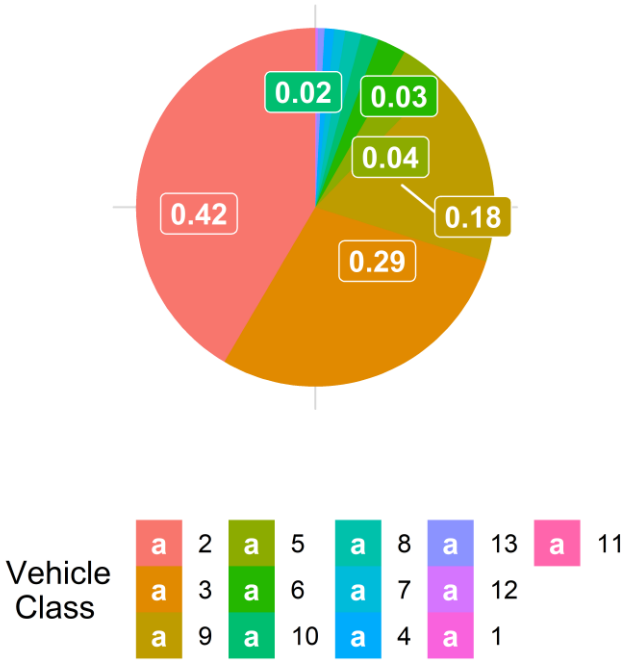


Figure 12 - Total ESALs by Class and Lane

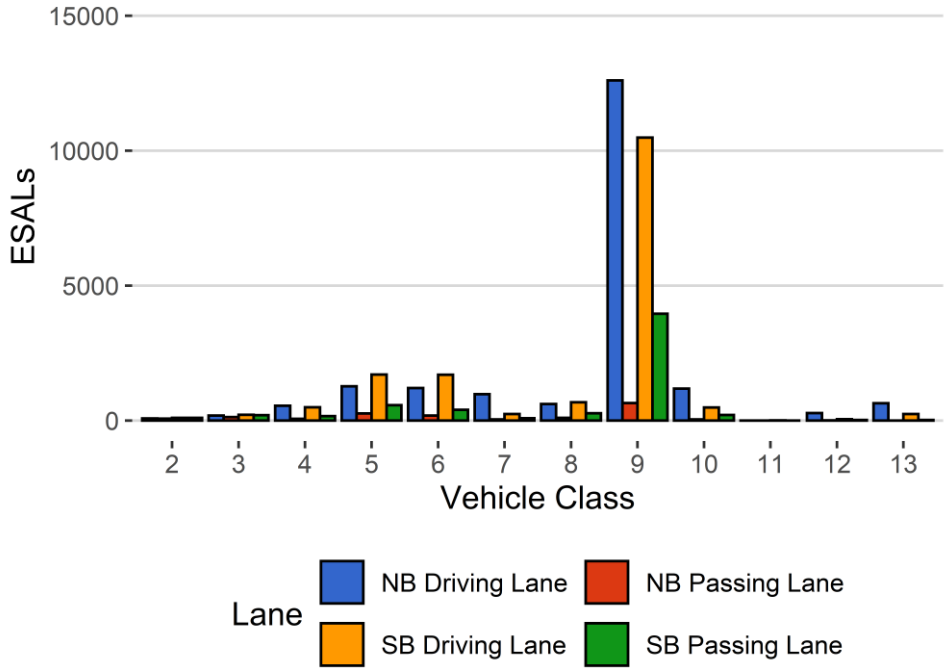


Figure 13 - ESALs by Class

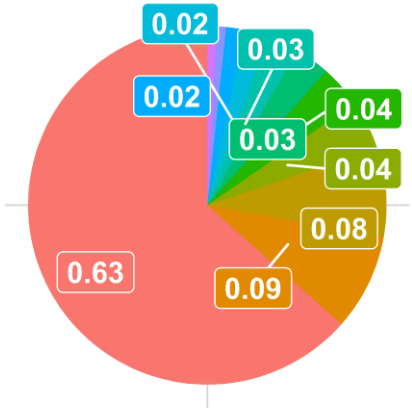


Table 1 Class 9 Front Axle Weight by Lane

Month	*Lane 1 (Kips)*	*Front Axle +/- 9%*	*Lane 2 (Kips)*	*Front Axle +/- 9%*	*Lane 3 (Kips)*	*Front Axle +/- 9%*	*Lane 4 (kips)*	*Front Axle +/- 9%*
June 2019	10.72	0.00	10.57	0.00	11.19	0.00	11.79	0.00
July 2019	10.75	0.31	10.61	0.38	11.12	-0.62	11.91	1.04
August 2019	10.77	0.46	10.56	-0.06	10.92	-2.39	11.81	0.17

Table 2 Vehicle Classification Data

Vehicle Class	*Monthly Average Daily Volume*	*Monthly Total Volume*	*Monthly Total Volume Percentage*	*Monthly Total Overweight Vehicles*	*Monthly Total Overweight Percentage*
1	36	1127	0.1	0	0
2	23685	734220	65.4	0	0
3	10609	328864	29.3	0	0
4	64	1986	0.2	138	1.5
5	614	19022	1.7	381	4.2
6	189	5855	0.5	448	4.9
7	36	1113	0.1	354	3.9
8	107	3322	0.3	188	2.1
9	768	23809	2.1	6631	72.7
10	60	1873	0.2	638	7
11	1	18	0	0	0
12	7	204	0	95	1
13	16	500	0	254	2.8
TOTAL	**36191**	**1121913**	**100**	**9127**	**100**

Table 3 Top 10 Gross Vehicle Weight, Class 9 and 10

Date	*Day of Week*	*Time*	*Vehicle Class*	*Direction*	*Lane*	*GVW (lbs)*
2019-08-27	Tuesday	17:05:29	10	NB	1	152.26
2019-08-13	Tuesday	13:58:56	10	SB	4	120.72
2019-08-09	Friday	20:12:20	9	SB	3	119.15
2019-08-07	Wednesday	11:44:57	9	SB	4	115.75
2019-08-09	Friday	16:27:42	9	SB	3	115.52
2019-08-20	Tuesday	11:13:27	9	SB	4	114.07
2019-08-29	Thursday	14:23:16	10	SB	4	113.89
2019-08-22	Thursday	21:47:38	9	SB	3	113.07
2019-08-22	Thursday	13:15:09	10	SB	3	111.95
2019-08-15	Thursday	09:20:23	9	NB	1	111.64

Table 4 Freight Summary

Vehicle Class	*Direction*	*Weight of Empty Vehicle (Kips)*	*Total Number of Vehicles*	*Number of Empty Vehicles*	*Percentage of Empty Vehicles*	*Total Weight of Vehicles with Freight (Kips)*	*Total Weight of Empty Vehicles (Kips)*	*Total Weight of Freight (Tons)*
4	NB	15	1059	136	12.8	30440	1743	8298
5	NB	8	9351	1122	12	124513	8158	29341
6	NB	19	2652	327	12.3	75084	5474	15454
7	NB	11.5	818	0	0	52905	0	21749
8	NB	31	1662	1002	60.3	26642	23281	3091
9	NB	33	12502	2732	21.9	582914	76864	130252
10	NB	33.5	1049	95	9.1	67654	2319	17847
11	NB	36.5	6	6	100	0	133	0
12	NB	36.5	169	1	0.6	11859	24	2863
13	NB	31.5	375	1	0.3	30303	29	9261
TOTAL	****	****	**29643**	**5422**	****	**1002313**	****	**238156**
Vehicle Class	Direction	Weight of Empty Vehicle (Kips)	Total Number of Vehicles	Number of Empty Vehicles	Percentage of Empty Vehicles	Total Weight of Vehicles with Freight (Kips)	Total Weight of Empty Vehicles (Kips)	Total Weight of Freight (Tons)
4	SB	15	879	70	8	28067	914	7966
5	SB	8	9213	462	5	137261	3408	33627
6	SB	19	3062	205	6.7	96546	3481	21132
7	SB	11.5	268	0	0	17093	0	7006
8	SB	31	1580	640	40.5	38944	14308	4902
9	SB	33	10734	3072	28.6	496986	84478	122070
10	SB	33.5	779	291	37.4	31808	8758	7730
11	SB	36.5	12	8	66.7	264	183	59
12	SB	36.5	30	1	3.3	2434	27	688
13	SB	31.5	113	0	0	11001	0	3721
TOTAL	****	****	**26670**	**4749**	****	**860404**	****	**208899**
GRAND TOTAL	****	****	**56313**	**10171**	**426**	**1862718**	**233581**	**447055**

Table 5 Gross Vehicle Weight by Class and Lane

Vehicle Class	*NB Driving Lane*	*NB Passing Lane*	*SB Passing Lane*	*SB Driving Lane*	*Total*	*Percentage*
1	263	345	455	284	1347	0
2	721326	682768	806832	703718	2914643	41.5
3	537856	446430	541142	481171	2006599	28.6
4	27626	4556	8032	20949	61163	0.9
5	98297	34374	52132	88538	273340	3.9
6	69009	11549	25365	74662	180584	2.6
7	50425	2480	5325	11768	69998	1
8	42057	7866	17892	35360	103175	1.5
9	606915	52862	205494	375971	1241242	17.7
10	66346	3627	15350	25215	110538	1.6
11	112	21	25	422	580	0
12	11663	220	748	1714	14345	0.2
13	29918	414	1180	9821	41333	0.6
TOTAL	**2261813**	**1247513**	**1679972**	**1829590**	**7018888**	**100**
GVW/LANE	**32.22**	**17.77**	**23.94**	**26.07**	**100**	**0**

Table 6 ESALs by Class and Lane and Flexible ESAL Factors

Vehicle Class	*NB Driving Lane*	*NB Passing Lane*	*SB Passing Lane*	*SB Driving Lane*	*Total*	*Percentage*	*Flexible ESAL Factor*
1	0	0	0	0	0	0	9e-04
2	80	78	105	99	361	0.83	0.001
3	191	134	203	214	742	1.7	0.0046
4	554	66	167	496	1283	2.94	1.32
5	1269	263	571	1708	3811	8.74	0.41
6	1210	187	399	1697	3493	8.01	1.22
7	980	44	88	247	1358	3.11	2.49
8	616	106	271	677	1670	3.83	1.03
9	12601	649	3960	10483	27693	63.47	2.39
10	1188	44	209	485	1926	4.41	2.1
11	0	0	0	7	7	0.02	0.85
12	282	7	26	52	367	0.84	3.54
13	646	4	21	247	919	2.11	3.7
TOTAL	**19616**	**1581**	**6020**	**16412**	**43630**	**100**	**19**
ESALS/LANE	**45**	**3.6**	**13.8**	**37.6**	**100**	**–**	**–**

Table 7 Site Summary: Volume and Vehicle Class

Month	*Total Volume*	*Monthly ADT*	*Monthly HCADT*	*Passenger Vehicles*	*Passenger Vehicles %*	*Heavy Commercial Vehicles*	*Heavy Commercial Vehicles %*	*Heavy Commercial Vehicles in Driving Lane %*	*Heavy Commercial Vehicles in Passing Lane %*
Sep 2018	1068437	35615	1806	1014244	94.9	54192.6	5.1	73.1	26.9
Oct 2018	1143679	36893	1932	1083787	94.8	59891.9	5.2	73.6	26.4
Nov 2018	980508	32684	1594	932691	95.1	47816.9	4.9	71.4	28.6
Dec 2018	921951	30732	1217	884226	95.9	37725.4	4.1	70.5	29.5
Jan 2019	912085	29422	1247	873418	95.8	38667.4	4.2	72	28
Feb 2019	795365	28406	1230	760938	95.7	34426.8	4.3	67	33
Mar 2019	973223	31394	1336	931796	95.7	41427.3	4.3	71.7	28.3
Apr 2019	1019560	33985	1544	973238	95.5	46322.3	4.5	72.1	27.9
May 2019	1118314	36375	1686	1066053	95.3	52260.7	4.7	71.6	28.4
Jun 2019	1096822	36561	1744	1044498	95.2	52323.8	4.8	70.1	29.9
Jul 2019	1100654	35362	1785	1045333	95	55321.1	5	71.7	28.3
Aug 2019	1121913	36075	1861	1064211	94.9	57701.6	5.1	72.4	27.6
TOTAL	**12252511**	**–**	**–**	**11674433**	**–**	**578078**	**–**	**–**	**–**
AVERAGE	**1021043**	**33625**	**1582**	**972869**	**95**	**48173**	**5**	**71**	**29**

###ESALs

Month	*ESALS NB Passing Lane*	*ESALS NB Driving Lane*	*ESALS SB Driving Lane*	*ESALS SB Passing Lane*	*Total ESALS*	*Driving Lane ESALS %*	*Passing Lane ESALS %*	*Pavement Life Decrease Months*
Sep 2018	13504	1314	3680	9789	28287	82	18	0.9
Oct 2018	14864	1239	4123	11960	32186	83	17	0.9
Nov 2018	11820	925	3283	9678	25705	84	16	0.7
Dec 2018	9672	743	2777	6999	20190	83	17	2.8
Jan 2019	8504	642	2895	6695	18736	81	19	1.3

Feb 2019	7396	843	2850	4522	15611	76	24	1.9
Mar 2019	8913	920	2731	6292	18856	81	19	0.5
Apr 2019	8652	896	2921	6854	19322	80	20	0.1
May 2019	10529	1103	5184	12002	28819	78	22	6.2
Jun 2019	28564	2771	13156	27126	71617	78	22	2.9
Jul 2019	17750	1504	6355	15850	41459	81	19	3.6
Aug 2019	19834	1591	6030	16437	43893	83	17	3.7
TOTAL	**160003**	**14489**	**55985**	**134204**	**364682**	**–**	**–**	**–**
AVERAGE	**13334**	**1207**	**4665**	**11184**	**30390**	**81**	**19**	**2**

###Gross Vehicle Weight

Month	*GVW NB Passing Lane*	*GVW NB Driving Lane*	*GVW SB Passing Lane*	*GVW SB Driving Lane*	*Total GVW Kips*
Sep 18	1969077	1086805	1443718	1567916	6067516
Oct 18	2278157	1216871	1631350	1776223	6902601
Nov 18	1807476	940472	1377348	1453973	5579269
Dec 18	1696068	847600	1282320	1192264	5018252
Jan 19	1596048	784003	1204798	1160173	4745021
Feb 19	1387374	715290	1084749	864793	4052206
Mar 19	1654804	918271	1249463	1251819	5074356
Apr 19	1746072	946867	1329617	1290655	5313211
May 19	1895521	1089661	1663992	1664481	6313656
Jun 19	4148155	2426300	3405678	3123961	13104094
Jul 19	2179409	1266094	1670241	1741373	6857117
Aug 19	2270498	1248079	1680800	1830923	7030299
TOTAL	**24628658**	**13486313**	**19024074**	**18918553**	**76057598**
AVERAGE	**2052388**	**1123859**	**1585339**	**1576546**	**6338133**

###Overweight Vehicles

Month	*Total Number of Overweight Vehicles*	*Overweight / Total Volume*	*Overweight / Heavy Commercial Volume*	*Number Over 88,000 lbs*	*Number Over 98,000 lbs*
Sep 2018	3238	0.3	6	163	57
Oct 2018	3922	0.3	6.4	195	70
Nov 2018	3672	0.4	7.8	127	42
Dec 2018	2606	0.3	6.9	144	17
Jan 2019	1949	0.2	5.1	96	10
Feb 2019	1628	0.2	4.7	81	20
Mar 2019	1385	0.1	3.4	70	22
Apr 2019	1064	0.1	2.3	40	17
May 2019	4468	0.4	8.8	393	103

Jun 2019	14060	0.7	13.9	1736	282
Jul 2019	8530	0.8	15.7	1384	182
Aug 2019	9199	0.8	16.2	1236	189
TOTAL	**55721**	**–**	**–**	**5665**	**1011**
AVERAGE	**4643.4**	**0.4**	**8.1**	**472.1**	**84.2**

###Freight

Month	*NB Freight Tons*	*SB Freight Tons*	*Total Freight*	*NB Freight %*	*SB Freight %*
Sep 2018	203714	164103	367817	55.4	44.6
Oct 2018	212665	187441	400106	53.2	46.8
Nov 2018	157880	147600	305480	51.7	48.3
Dec 2018	125562	112167	237729	52.8	47.2
Jan 2019	114896	109750	224646	51.1	48.9
Feb 2019	102376	83792	186168	55	45
Mar 2019	125458	111529	236987	52.9	47.1
Apr 2019	129728	127691	257419	50.4	49.6
May 2019	145149	190653	335802	43.2	56.8
Jun 2019	376690	385390	762081	49.4	50.6
Jul 2019	217482	209237	426719	51	49
Aug 2019	238156	208899	447055	53.3	46.7
TOTAL	**2149758**	**2038251**	**4188009**	**–**	**–**
AVERAGE	**179146.5**	**169854.3**	**349000.7**	**51.6**	**48.4**